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Amendment Dated August 8, 2005
Reply to Office Action of June 3, 2005

REMARKS/ARGUMENTS

Claims 1-36 and 52-56 remain in this application for further review. Independent claims

1, 5, 6, 12, 17, 22, 27, 32, 52, and 55 have been amended for the reasons more fully set forth

below. No new matter has been added.

I.   Brief Summary of Formal Examiner Interview

A Formal Examiner Interview was held at 11:00 a.m. (EST) on July 6, 2005. This

Response is formulated in light of this interview. During the interview, applicant's attorney and

Examiner Kang discussed the differences between the cited references and the present invention.

Applicant's attorney believes that an agreement was reached that the changes set forth herein

distinguish the current art cited in the most recent Office Action. The matter discussed during

the interview is more fully set forth in the below sections.

## II.   Rejection Under 35 U.S.C. §112, First Paragraph

Claims 17-21 are rejected under 35 U.S.C. §112, first paragraph, as failing to comply

with the written description requirement. Specifically, it is asserted that claim 17 contains a new

matter, "an assignment of an address of a first variable," which is not supported by the

specification. During the Examiner Interview, Examiner Kang requested that the element "of an

address" be removed for clarification purposes. Applicant's attorney believes that an agreement

was reached that claims 17-21 would be allowable under 35 U.S.C. §112, first paragraph, if this

element was removed from claim 17. Applicant has amended claim 17 accordingly.

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III. Rejection Under 35 U.S.C. §103(a)

Claims 1-16, 22-36 and 52-56 are rejected under 35 U.S.C. 103(a) as being unpatentable

over "Points-to Analysis in Almost Linear Time" by Bjarne Steensgaard (hereinafter

"Steensgaard") in view of "Program Analysis and Specialization for the C Programming

Language" by Lars Ole Andersen (hereinafter Andersen). Applicant respectfully disagrees with

the rejection. In hopes of clarifying several points between the present invention and the prior

art, applicant proposes the following Figure and accompanying explanation. The following is

but one example related to the prior art and the present invention and is meant for explanatory

purposes only. The following explanation is not meant to limit the scope of the claims in any

manner, in that, applicant believes the claims stand as written.

A. Explanation of Steensgaard, Andersen and the Present Invention
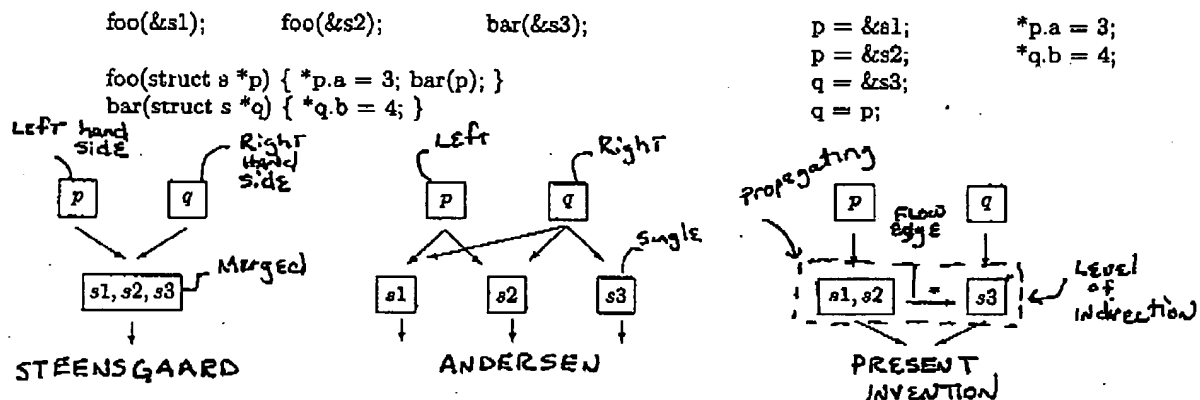
The above Steensgaard figure shows the points-to information computed by

Steensgaard's algorithm for the program in the Figure. The points-to graph shown contains

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nodes representing equivalence classes of symbols, and edges representing pointer relationships. Every node contains a single pointer edge. Stensgaard's algorithm processes assignments bidirectionally: The left hand side and right hand side memory locations in an assignment are constrained to hold the same contents. For the example program, the effect of the assignment from p to q is to force both p and q to point to the equivalence class containing $s1$, $s2$, and $s3$, even though p cannot point to $s3$ in any execution of the program. Steensgaard's algorithm uses type equality rules to merge equivalence classes of symbols at assignments, leading to nodes with single outdegree in the points-to graph. Since the nodes are merged, the use of Steensgaard's analysis only allows for an approximation. Such an approximation may be insufficient in many cases.

The above Andersen figure shows the points-to information computed by Andersen's algorithm. In this case, every node is associated with a single symbol, and contains a set of pointer values. Assignments are processed directionally: The content of the right hand side location are copied to the left hand side. Insofar as each symbol is pointed-to, this method produces expensive points-to sets as a result. Andersen's algorithm achieves directionality in assignments by using subtyping rules. In order to accommodate directionality, it is necessary to allow unlimited fanout, or outdegree, in the points-to graph. This leads to trees with fanout at all directions. The algorithm is expensive because of the work required to track the subtyping relations induced at all levels of the points-to graph.

The above figure for the present invention shows a method for enhancing pointer analysis. The pointer analysis includes associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate

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a label of the first one of the two locations to a label of the second one of the two locations such

that the label of the first one of the two locations is a subset of the second one of the two

locations (shown by the "*" flow edge). The two locations are selected to be one level of

indirection away for a level associated with the assignment. Thus, the pointer target location of p

contains $s1$ and $s2$, whereas the pointer target location of q contains $s1$ and $s2$, as well as $s3$. In

this manner, the present invention allows unlimited outdegree in critical areas, while restricting

outdegree in other non-critical areas. The present invention is, therefore, inexpensive and

accurate in use.

B.   Elements of the Claims Not Taught Or Otherwise Suggested by the Cited References

Claim 1 recites the following elements that are not taught or suggested in the above-cited

references:

"processing an assignment between two variables in a program, wherein processing an assignment includes *forming a relationship between two locations that are related to the two variables, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment, wherein each location includes a label and a content*"

"*associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations*"

Claim 5 recites the following elements that are not taught or suggested in the above-cited

references:

"processing an assignment between two variables in a program, wherein processing an assignment includes *forming a relationship between two locations that are related to the two variables, wherein the two locations are selected to be one level of indirection away from a level associated with the assignment, wherein each location includes a label and a content*"

*"associating a flow edge with the first one of two locations and the second one
of two locations, wherein the flow edge is configured to propagate a label of the
first one of the two locations to a label of the second one of the two locations
such that the label of the first one of the two locations is a subset of the second
one of the two locations"*

Claim 6 recites the following elements that are not taught or suggested in the above-cited

references:

*"defining a relationship between two locations upon an assignment in the
program, wherein the two locations are selected to be one level of indirection
away from a level associated with the assignment "*

*"associating a flow edge with the first one of two locations and the second one
of two locations, wherein the flow edge associates a label of the first one of the
two locations to a label of the second one of the two locations such that the
label of the first one of the two locations is a subset of the second one of the two
locations"*

Claim 12 recites the following elements that are not taught or suggested in the above-

cited references:

*"forming a relationship between two locations upon an assignment of a first
variable and a second variable in the program, wherein the two locations are
selected to be one level of indirection away from a level associated with the
assignment"*

*"associating a flow edge with the first one of two locations and the second one
of two locations, wherein the flow edge is configured to propagate a label of the
first one of the two locations to a label of the second one of the two locations
such that the label of the first one of the two locations is a subset of the second
one of the two locations"*

Claim 17 recites the following elements that are not taught or suggested in the above-

cited references:

*"forming a relationship between two locations upon an assignment of a first
variable and a second variable in the program, wherein the two locations are
selected to be one level of indirection away from a level associated with the
assignment"*

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> *"associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations"*

Claim 22 recites the following elements that are not taught or suggested in the above-cited references:

> "forming a relationship between two locations upon an assignment of a first variable and a dereference of a second variable in the program, *wherein the two locations are selected to be one level of indirection away from a level associated with the assignment"*

> *"associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations"*

Claim 27 recites the following elements that are not taught or suggested in the above-cited references:

> "forming a relationship between two locations upon an assignment of a dereference of a first variable and a second variable in the program, *wherein the two locations are selected to be one level of indirection away from a level associated with the assignment"*

> *"associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations"*

Claim 32 recites the following elements that are not taught or suggested in the above-cited references:

> "defining a relationship between two locations upon an assignment in the program, *wherein the two locations are selected to be one level of indirection away from a level associated with the assignment"*

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> *"associating a flow edge with the first one of two locations and the second one of two locations, wherein the flow edge is configured to propagate a label of the first one of the two locations to a label of the second one of the two locations such that the label of the first one of the two locations is a subset of the second one of the two locations"*

Claim 52 recites the following elements that are not taught or suggested in the above-cited references:

> "establishing a plurality of flow relationships corresponding to each of the plurality of assignment statements, *wherein each of the flow relationships is selected to be established one level of indirection away from each of the assignment statements, and wherein the flow relationship includes a flow edge configured to propagate a label such that the label of one of the plurality of sets of information is a subset of another of the plurality of sets of information."*

Claim 55 recites the following elements that are not taught or suggested in the above-cited references:

> "an analyzer to analyze the tree to produce an object file, wherein the object file contains at least one relationship between two variables in an assignment statement in the program, *wherein the relationship includes a flow edge that defines that a set of symbols relating to one of the two variables is a subset of a set of symbols relating to the other of the two variables, and wherein the relationship is selectively formed one level of indirection away from a level associated with the assignment statement between the set of symbols related to one of the two variables and the set of symbols relating to the other of the two variables"*
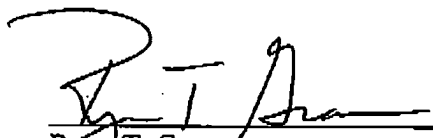
As is evident from the above highlighted claims and the discussion in Section II of this Response, independent claims 1, 5, 6, 12, 17, 22, 27, 32, 52, and 55 are not taught or otherwise suggested by the cited references. Insofar as the remaining claims depend from independent claims 1, 5, 6, 12, 17, 22, 27, 32, 52, and 55, they are thought to be allowable for at least those same reasons. Applicant respectfully requests allowance of all the claims.

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In view of the foregoing amendments and remarks, all pending claims are believed to be allowable and the application is in condition for allowance. Therefore, a Notice of Allowance is respectfully requested. Should the Examiner have any further issues regarding this application, the Examiner is requested to contact the undersigned attorney for the applicant at the telephone number provided below.

Respectfully submitted,

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